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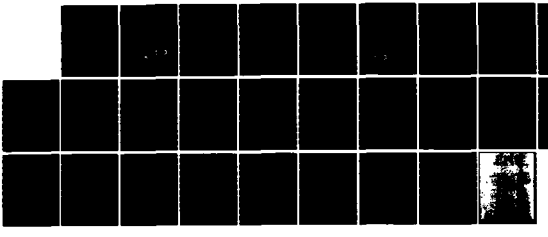

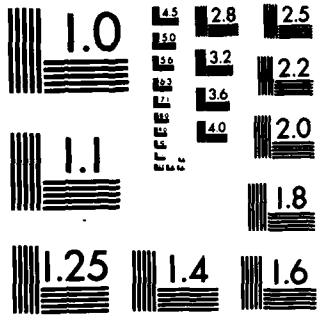

NRL Memorandum Report 5352

Software for a Computer Controlled Laser Doppler Velocimeter

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Combustion and Fuels Branch
Chemistry Division

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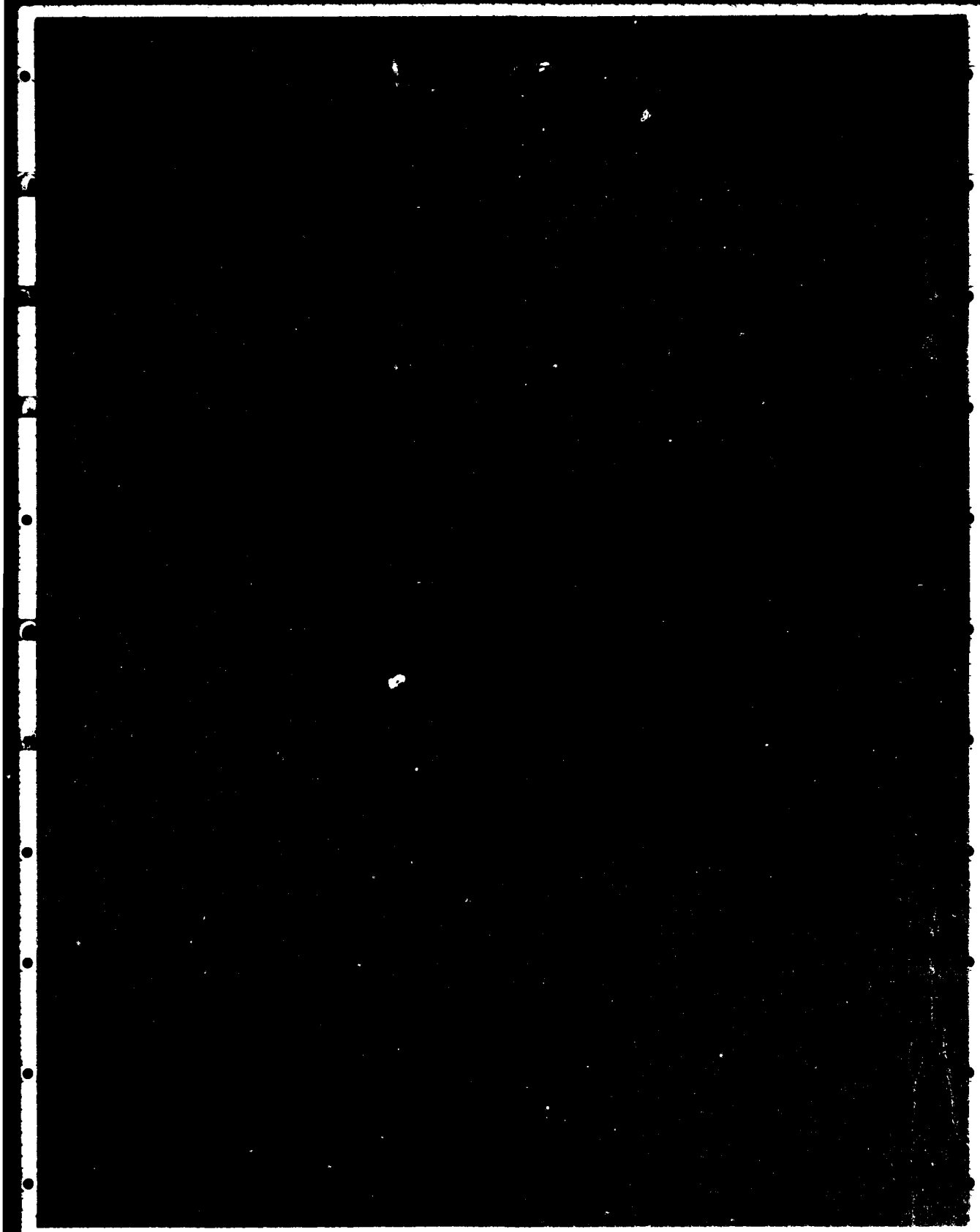
NAVAL RESEARCH LABORATORY
Washington, D.C.



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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Software, consisting of a main FORTRAN program and an assembly language driver, has been developed for the computer control of a laser doppler velocimeter (LDV). This is part of a continuing effort in the use of the LDV to measure turbulence in combustion processes. A brief discussion of the LDV hardware is included. An illustrative example follows to demonstrate software capabilities.

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CONTENTS

SOFTWARE FOR A COMPUTER CONTROLLED LASER DOPPLER VELOCIMETER

I. INTRODUCTION

The hazard associated with fire in confined spaces is critical to the Navy due to the vulnerability of a ship to the disastrous effects of an uncontrollable fire. An understanding of the physical mixing processes in diffusion flames, which are characteristic of most unwanted fires, is necessary. By knowing the mixing patterns, a better understanding of fire growth in confined areas can be developed. This ultimately will lead to ways of controlling materials, geometry, design and structure to fire harden our ships more. The need for better mixing information has prompted research efforts toward the development of a technique to measure turbulence in combustion processes using laser doppler velocimetry (LDV).

The LDV is a state-of-the-art diagnostic tool to measure the velocity of particles moving in a flow field. The ability to characterize highly turbulent flow fluctuations at near zero mean velocity and to make measurements without obstructing the flow makes turbulence measurement via LDV preferable to that of other developed methods, such as the hot wire anemometer. The inability of the hot wire anemometer to measure turbulence in smoke-laden environments makes the LDV approach particularly attractive (1,2).

The principle behind laser doppler velocimetry lies in the phenomenon that particles suspended in a flow field will scatter laser light that is directed upon them. The frequency of the scattered light depends on the particle velocity and the angle through which the light has been scattered. The frequency of the scattered light is different from the frequency of the incident laser light. This frequency difference is the doppler frequency, which can be detected by electronic processing.

This is a continuing research effort, the result of which, to date, has been the development of computer software to control the LDV system. An example run follows, for illustrative purposes in demonstration of the software capabilities.

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II. EQUIPMENT

The LDV System (Disa Electronics) is comprised of a two-color laser and associated optics, two counter processors, electronic frequency shifters, and a buffer interface. Figure 1 illustrates the overall schematic of the LDV system. The pieces of the equipment describing the LDV System are described below.

II. A. LASER

The blue/green colored beam from a four watt, argon ion laser is passed through a series of color-neutral and color-separating beam splitters to create three beams, blue/green, green and blue, as shown in Figure 2. The three beams are focused by the transmitting optics to an intersection point, approximately 16 feet from the laser where the fluid whose flow patterns are being measured is located. The purpose of choosing such an unusually large focal length (most LDV systems employ a three to four foot focal length) is to have the capability, when necessary, to make measurements during large scale fire tests where it is desirable to keep the hardware at a sufficiently large distance from the fire source.

The intersection of the green and blue/green beams results in the formation of interference fringes. A particle from the flow field which passes through the interference fringes scatters light, the intensity of which rises and falls as the particle moves from bright fringe to dark fringe. This scattered light is collected on a photomultiplier tube in the backscatter mode and converted to a frequency-modulated current burst. Further processing occurs in the counter processors (as discussed below) to give the vertical component of velocity of the particle in the flow field. The intersection of the blue and blue/green beams similarly creates interference fringes from which a particle passing through scatters light. This scattered light is collected on a second photomultiplier tube, converted to a doppler signal, and further processed in the second counter processor to give the horizontal velocity component of the same particle in the flow field.

II. B. COUNTER PROCESSOR

The frequency-modulated current burst from each of the photomultipliers is amplified and band-pass filtered in separate counter processors. Each burst represents the passage of a single particle and contains information on the number of fringes passed by the particle. The frequency of the doppler burst signal is detected by internal logic circuitry. The distance between the fringes is known from the geometry of the optical beams and the wavelength of the laser

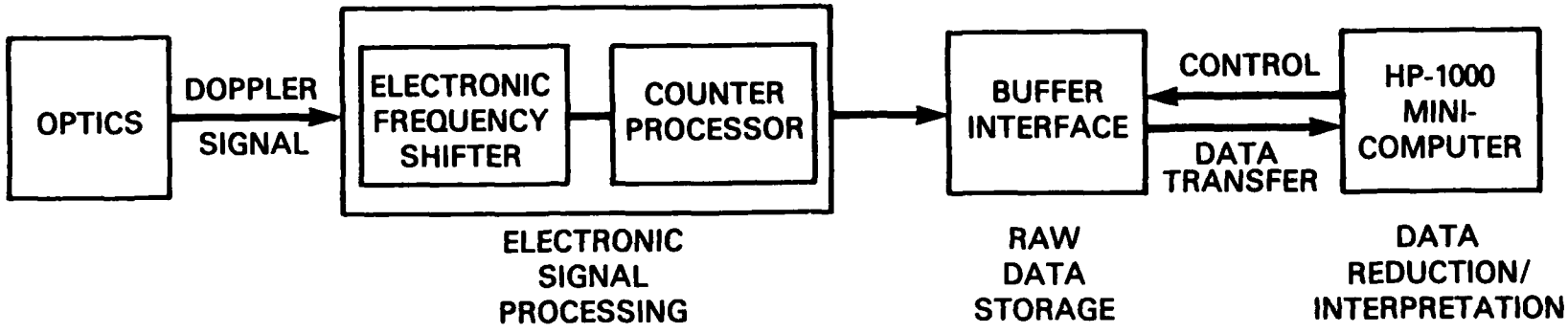

Figure 1. Schematic of LDV System

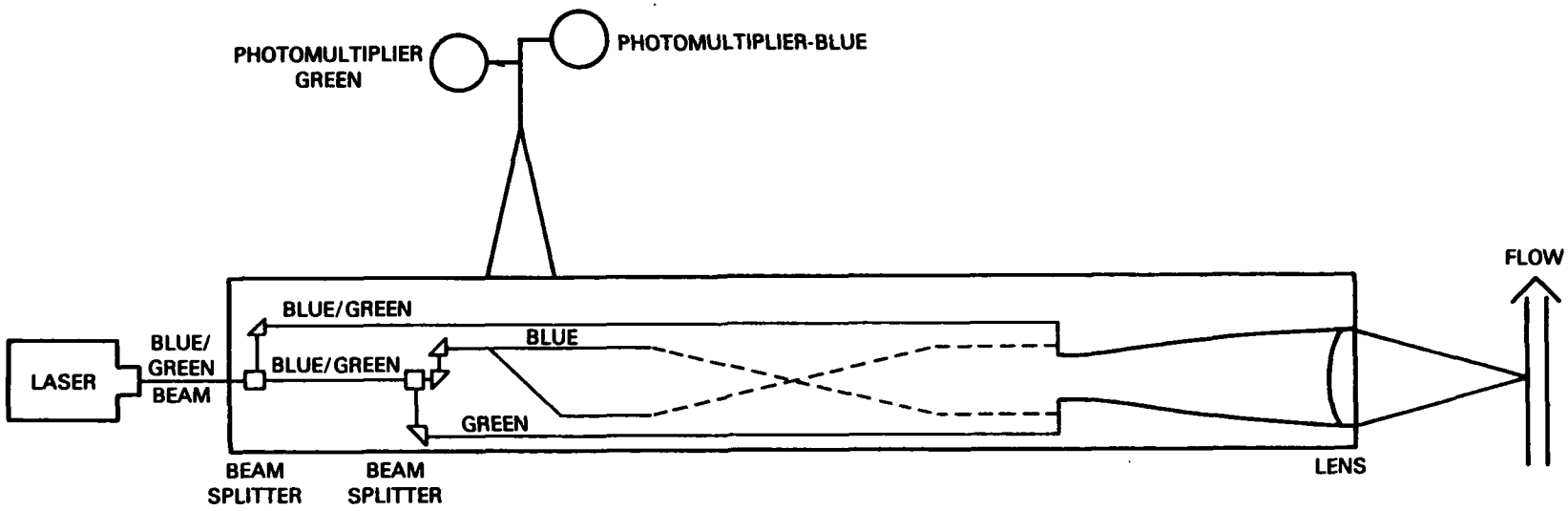

Figure 2. Optical arrangement in backscatter mode resulting in separate blue, green and combination blue/green laser beams, which intersect to form interference fringes. Particles in flow-field scatter light, the intensity of which rises and falls as the particle moves from bright fringe to dark fringe.

line. Instantaneous particle velocity may then be calculated by multiplying the fringe spacing by the measured doppler signal frequency.

The counter processors have the capability to send four types of data to the buffer interface. Doppler frequency data and sample interval time (time interval between each successive validated signal) data are contained on the pins of one of the rear panel multi-connectors of the counter processor. The other gives information on the number of fringes and burst time, i.e., time between each doppler burst.

II. C. BUFFER INTERFACE

The Buffer Interface acts as a data and control interface in the transfer of digital data between the counter processors and the Hewlett-Packard-1000 mini-computer. It functions as a buffer memory for the randomly arriving data from the counter processors before it is transferred to the HP-1000. It also receives the control words from the computer, as written in the software, so that the LDV will operate with the appropriate data and control channels opened.

Synchronization within a selected time interval between the data from the two counter processors is achieved with the coincidence filter board inside the Buffer Interface. The selection of input and output channels and the setting of coincidence time intervals are all software-controlled.

The Buffer Interface has been designed to interface with the DEC PDP-11 mini-computer family. An additional circuit board was added to the Buffer Interface which converts the control and data format to that of the HP Microcircuit Board 12566B for Hewlett Packard mini-computer in the 2100 series.

Data are transferred from the additional interface board, with a 16 bit, parallel full duplex format, to the 12566 Board of the HP 21MX series mini-computer. The 12566 Board has 16 bit input and output registers. A system of electronic "handshakes" controls the signal and data lines, as described in the software section of this report.

III. SOFTWARE

The transfer of information to and from the LDV is software controlled. Control of the LDV by the HP-1000 computer is achieved by a software driver. The driver is called by the main FORTRAN program, program LDV, both of which were written at the Naval Research Laboratory (NRL) and are discussed in the following sections.

III. A. DRIVER

A relocatable HP-assembly language driver was written to enable the computer to communicate with the LDV Buffer Interface. The driver, as shown in Appendix A, is FORTRAN callable, and contains all of the necessary "set control," "set flag," etc. instructions to control and read data from the LDV.

A non-interrupt data transfer method was chosen due to the higher degree of ease with which this type of driver could be written compared to that of an interrupt-type driver. The non-interrupt method involves a "wait-for-flag" routine when inputting LDV data into the data-register. The computer signals the interface card to start the LDV device. The driver loops until the LDV is ready to input data into the data-register. Readiness to input data is expressed by setting a flag flip-flop. After the flag is set, the program continues. At times, the doppler signal is of insufficient strength to cause the flag to set. To prevent the driver from looping indefinitely, a routine to wait 1000 times for the flag was incorporated. If the flag does not set after 1000 attempts, the program is terminated. The wait-for-flag routine is not required when outputting control words from the computer to the LDV.

The memory protect logic feature, which is incorporated in the HP-1000 Real Time Executive operating system, limits control of all Input/Output operations to interrupt control only. Thus, the memory protect fence is disabled by assembly language software, so that the non-interrupt driver has control of the LDV.

The driver consists of two main segments, the initiation section and the continuation section. The initiation section performs two basic functions: (a) to clear the buffer memory before a new record of data is to be entered, and (b) to send the control words to the LDV.

The collection of data is accomplished in the continuation section. Counting variables are incremented each time a data word is collected so that data rate can be acknowledged. The memory protect fence is re-enabled after a buffer of data is collected. This gives the interrupt system control of the input/output peripheral devices before returning to main FORTRAN program. Three control words are sent to the LDV which open up appropriate channels for data collection. The control words, which are collected in the initiation section of the driver and are sent out in the main program, perform three functions.

The first word turns on the coincidence filter board and opens up channels 1 and 2. The second control word sets the time interval between successive samples to 125 microseconds. This will ensure that the data from the two counter processors will be synchronized within this time interval. The third control word is the static control word and must remain set during operation. Channels 1 and 2 (connected with the counter processors) and channel 4 (connected with the Coincidence Filter Board) are opened for input. Doppler frequency data and sample interval data may be simultaneously collected from one of the multi-connectors on the counter processor; fringe number and burst time data are simultaneously collected from the other.

Because the 12566 Board does not give a data transmitted signal after a data word has been read into the computer, this signal is created artificially by transmitting a device command signal with the address of octal 60000. In both the initiation and continuation sections, the number 60000 (octal) is loaded into the B register. The instructions OTB LDV (output the contents of the B register to the LDV) and STC LDV (set the control flip flop on the LDV interface card in the computer I/O cage) result in the artificial creation of a data transmitted signal.

III. B. PROGRAM LDV

The main FORTRAN program, as shown in Appendix B, is comprised of three main sections which contain calls to the assembly language driver and calls to several subroutines. The first segment is used to test the LDV by taking samples and writing this out to any terminal. The user may specify any control words that are desired. This is a good way to test to see if the different channels which are opened are actually sending data.

The second segment is used to collect data for a user-specified amount of time and writes the raw data to a created disc file. The maximum number of 512 data transfer words can be collected in a record, as this is the size of buffer memory in the Buffer Interface. The number of data words collected, represented by the variable ICNT, is one of the variables passed to the driver from the main program, which enables the calculation of data rate.

Segment number three is used to sort and assemble the raw data collected on the disc file created by segment number two. A second data file is created which contains the sorted data. This segment reads in a record of data of up to 512 words from the raw data file. Subroutine ASMBL, which is then called, evaluates each data word based on the type of information that corresponds to each of the 16 bits comprising the data words.

This information is passed to subroutine SORT which identifies the data as either doppler frequency data, sample interval data, number of fringes data, or burst time data. Doppler frequency data is converted to velocity, by the following relationship:

Velocity = Doppler Frequency x Fringe Spacing

where

$$\text{Fringe Spacing} = \frac{\lambda}{2 \sin \theta/2}$$

λ = laser wavelength

θ = angle of intersection of laser beams

Summations of the velocity data are performed in Subroutine STAT for the purpose of calculating average velocity at a subsequent point in the program. Subroutine GATHR groups the velocity and sample interval time data by burst and writes the assembled data to the output file. At this point, program statement number 310, the program loops back up to program statement number 309 to read the next record of data of up to 512 words from the raw data file.

After the final record of data has been written to the output file, Subroutine STAT calculates average velocity for each of the counters, i.e., horizontal and vertical component, and the magnitude and direction of the resultant velocity vector.

IV. EXAMPLE RUN

The following example is intended as an illustration of the utility of the software in transferring information to and from the LDV.

The vertical and horizontal components of velocity were measured in a test run for one point in a 6 cm methanol pan fire. The laser beam intersected at a vertical position 1 cm above the lip of the pan and in the center of the pan in the horizontal direction. The liquid level of methanol was maintained constant (3). Data were collected for approximately 30 minutes.

The lack of formation of soot particles in the methanol flame, due to methanol's clean burning characteristics, creates some difficulty with LDV measurement. The principle behind the LDV technique rests in the fact that particles in the flow field will scatter laser light that is directed upon them. A very sparse particle concentration, such as with

methanol, results in a very low data rate and small amplitude doppler bursts. A doppler signal of amplitude less than 200 millivolts will not be validated in the counter processors, resulting in a near zero data rate. The unusually long focal length of 16 feet also contributes to a smaller doppler signal in comparison to a short focal length, as the light scattered from the particles in the flow field travels a longer distance before being collected in the photomultiplier tube. The longer distance travelled by the scattered light results in reduced signal strength.

In this run, the doppler signal was boosted by adding small amounts of n-heptane to the fuel pan. This resulted in a more soot-laden flame of orange color. The flame was placed inside a wooden box with several small cut-out holes for ventilation. The box served to stabilize the flame from the air currents created by the nearby hood and air ducts, as well as to elevate the smoke particle concentration near the flame to boost the doppler signal strength.

Appendix C contains a listing of the data which has been grouped by doppler burst. Column #2 lists velocity in the vertical direction (meters per sec), column #3 lists velocity in the horizontal direction, and column #4 gives the sample interval time for that doppler burst from which the data is generated. For the vertical component, a positive number indicates the upward direction, while negative indicates downward. A positive number for the horizontal component indicates a direction to the right. After processing all of the data, the unweighted mean velocity, as calculated from all the data points, is shown along with the angle of the velocity vector, in reference to the vertical position.

V. CONCLUSIONS

In a continuing effort to understand the physical mixing processes in diffusion flames, NRL is currently involved in the development of a technique to measure the velocity profile in combustion processes using the laser doppler velocimeter. To date, the software has been developed for a computer-controlled LDV. Further work is required in the areas of seeding the flow field to boost the signal to noise ratio of the doppler signal to make this a viable research tool.

VI. REFERENCES

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2. Stevenson, W. H., Thompson, H. D. and Gould, R. D., "Laser Velocimeter Measurements and Analysis in Turbulent Flows with Combustion, Part II," School of Mechanical Engineering, Purdue University, Report No. AFWAL-TR-82-2076, July 1983.

3. Alexander, J. I., St. Aubin, H. J., Stone, J. P., Street, T. T. and Williams, F. W., "Large-Scale Pressurizable Fire Test Facility - FIRE I," NRL Formal Report 8643, 30 December 1982.

APPENDIX A - SOFTWARE DRIVER

```
:&DRVR  T=00003 IS ON CR00041 USING 00015 BLKS R=0000

0001  ASMB,R,L
0002        NAM DRVR,7   USER WRITTEN DRIVER(SELECT CODE=10B)
0003        ENT DRVR
0004        EXT .ENTR,$LIBR,$LIBX
0005  *
0006  * FIND ADDRESSES OF PASSED VARIABLES
0007  ICODE NOP
0008  IDATA NOP
0009  IDL   NOP
0010  ISCW  NOP
0011  ISL   NOP
0012  ICNT  NOP
0013  IFLAG NOP
0014  DRVR  NOP
0015        JSB .ENTR
0016        DEF ICODE
0017  *
0018  * DEFINE SELECT CODE OF 12566 BOARD
0019  LDV   EQU 10B
0020  *
0021  * DETERMINE TASK:
0022        LDA ICODE,I       ICODE=1 DO INITIATION SECTION ONLY
0023        CPA TWO           ICODE=2 DO CONTINUATION SECTION ONLY
0024        JMP CONT          ICODE=3 DO BOTH SECTIONS
0025  ********************************************************************
0026  * INITIATION SECTION:                                              *
0027  ********************************************************************
0028        LDB DC         KEEP 60000B IN B
0029        LDA K1         SAVE MEMORY SIZE TO CLEAR
0030        CMA,INA
0031        STA CNT1
0032        LDA ISL,I      USE ISCW LENGTH AS A COUNTER
0033        CMA,INA
0034        STA CNT2
0035        LDA ISCW       SAVE ADDRESS OF CONTROL BUFFER
0036        STA PTR1
0037  *
0038  * DISABLE THE MEMORY PROTECT FENCE
0039        JSB $LIBR      GO PRIVILEGED
0040        NOP                  *
0041  *
0042  * CLEAR THE USED BUFFER MEMORY
0043  CLEAR NOP
0044        OTB LDV
0045        STC LDV,C
0046        CLC LDV
0047        ISZ CNT1
0048        JMP CLEAR
0049  *
0050  * SEND OUT CONTROL WORDS TO INTERFACE
0051  SEND  LDA PTR1,I
0052        OTA LDV
0053        STC LDV,C
0054        CLC LDV
0055        ISZ PTR1     INCREMENT BUFFER ADDRESSES
0056        ISZ CNT2     AND COUNTER
0057        JMP SEND
0058  *
```

```
0059  * RETURN IF ICODE=1
0060        LDA ICODE,I
0061        CPA ONE
0062        JMP BYE
0063  ********************************************************************
0064  * CONTINUATION SECTION :                                           *
0065  ********************************************************************
0066  CONT  NOP
0067        LDA ONE           ASSUME A SUCCESSFUL CALL
0068        STA IFLAG,I
0069        LDA IDL,I         USE BUFFER SIZE AS A COUNTER
0070        CMA,INA
0071        STA CNT3
0072        LDA IDATA         STORE ADDRESS OF DATA BUFFER
0073        STA PTR2
0074        LDB DC            KEEP 600008 IN B-REG
0075        LDA ZERO          INITIATE DATA COUNTER
0076        STA ICNT,I
0077  *
0078  * IF ICODE=3 NO NEED TO TURN OFF OPERATING SYSTEM
0079        LDA ICODE,I
0080        CPA THRE
0081        JMP MORE
0082  *
0083  * TURN OFF OPERATING SYSTEM
0084        JSB $LIBR
0085        NOP
0086  *
0087  * COLLECT DATA TRANSFER WORDS
0088  MORE  NOP
0089        LDA THOU
0090        STA WAIT
0091        OTB LDV
0092        STC LDV,C
0093  LIST  NOP
0094        SFS LDV
0095        JMP IMP
0096        LIA LDV
0097        CPA ZERO            PREVENT ZEROES FROM ENTERING
0098        JMP MORE            BUFFER MEMORY
0099        STA PTR2,I
0100        ISZ PTR2
0101        NOP
0102        ISZ ICNT,I
0103        NOP
0104        ISZ CNT3
0105        JMP MORE
0106  *
0107  * ENABLE THE MEMORY PROTECT FENCE & RETURN
0108  BYE   NOP
0109        CLC LDV
0110        CLF LDV
0111        JSB $LIBX         GO UNPRIVILEGED
0112        DEF *+1                 "
0113        DEF *+1                 "
0114        JMP DRVR,I
0115  *
0116  * ROUTINE TO WAIT THOU TIMES FOR FLAG
0117  IMP   NOP
0118        ISZ WAIT
```

```
0119            JMP LIST
0120            LDA TWO
0121            STA IFLAG,I
0122            CLC LDV
0123            CLF LDV
0124            JSB $LIBX
0125            DEF *+1
0126            DEF *+1
0127            JMP DRVR,I
0128    *
0129    *
0130    * VARIABLE STORAGE
0131    DC      OCT 60000
0132    K1      DEC 512
0133    ZERO    DEC 0
0134    ONE     DEC 1
0135    TWO     DEC 2
0136    THRE    DEC 3
0137    THOU    DEC -32000
0138    CNT1    NOP
0139    CNT2    NOP
0140    CNT3    NOP
0141    PTR1    NOP
0142    PTR2    NOP
0143    WAIT    NOP
0144            END
```

APPENDIX B - MAIN FORTRAN PROGRAM

```
&LDV   T=00003 IS ON CR00041 USING 00094 BLKS R=0000

0001  FTN4,L
0002  C-------------------------------------------------------------C
0003  C                                                             C
0004        PROGRAM LDV(3,91),  REV 830720- TO USE THE LDV
0005  C                                                             C
0006  C     WRITTEN BY STEVE LUSTIG AND CAROLYN KAPLAN               C
0007  C
0008  C-----FUNCTIONS:-----------------------------------------------C
0009  C 1) TO TEST THE COINCIDENCE FILTER BOARD                     C
0010  C 2) TO OPERATE THE DISA LASER DOPPLER ANEMOMETER             C
0011  C    SYSTEM HARDWARE FROM HP-21MX SOFTWARE                    C
0012  C 3) TO COLLECT DATA FROM DISA LASER DOPPLER ANEMOMETER       C
0013  C    BUFFER INTERFACE                                         C
0014  C 4) TO CREATE DISK/TAPE FILES OF THIS DATA                   C
0015  C 5) TO ASSEMBLE DATA & WRITE OUT ON LP (LU6)                 C
0016  C 6) TO COMPUTE REYNOLD'S STRESS CORRELATIONS (& ETC)         C
0017  C    FROM ASSEMBLED DATA                                      C
0018  C                                                             C
0019  C---- MISCELLANEOUS-----------------------------------------C
0020  C 1) THE DRIVER OPERATING THE LDV IS CURRENTLY A              C
0021  C    RELOCATABLE VERSION WHICH IS LOADED WITH THIS PROGRAM.    C
0022  C    THE VARIABLES PASSED TO THE DRIVER(&DRVR) MUST NOT BE    C
0023  C    CHANGED.                                                 C
0024  C 2) THE LAST WORD IN ARRAY SCW MUST BE THE 'STATIC CONTROL   C
0025  C    WORD' WHICH IS USED TO 'TURN ON' DESIRED CHANNELS. PRE   C
0026  C    CEEDING CONTROL WORDS OPERATE PERIPHERAL BOARDS/DEV.S.   C
0027  C 3) THE SORTING ROUTINE [MODE=3] WILL MOST LIKELY HAVE TO    C
0028  C    BE MODIFIED AS MORE HARDWARE IS ADDED TO THE LDV SYS     C
0029  C 4) RUNNING THIS PROGRAM WITH THE FTN4,D OPTION WILL ACTI-   C
0030  C    VATE PRINTING SUBROUTINES IN TASK 3.
0031  C-------------------------------------------------------------C
0032  C
0033        COMMON LU(5)
0034        INTEGER ISCW(10),IDATA(512),IFLAG,TITLE(20),IDCB(656)
0035        INTEGER TAPELU,ITIME(5),IBUFF(20),IDCB2(144),NAME(3)
0036        INTEGER NAME2(3),PLOC,PARTCH,STIME,ICNT,WAIT
0037        REAL FTI,FTW,FTC,TTI,DT,COUNT,FORM1,FORM2,RDATA
0038        DATA TITLE/40*2H  /
0039  C
0040  C----DETERMINE THE LU OF THE DEVICE-------------------------
0041  C
0042        CALL RMPAR(LU)
0043  C
0044  C----DETERMINE TASK-----------------------------------------
0045  C
0046    2   WRITE(LU,3)
0047    3   FORMAT(1X,'ENTER:    1    TO TEST LDV BY TAKING SAMPLES'
0048       +/17X,'(WRITE TO ANY NON-DISC LU)'
0049       +/11X,'2    TO COLLECT DATA FROM THE LDV INTERFACE'
0050       +/17X,'(COLLECT FOR A GIVEN AMOUNT OF TIME,'
0051       +/17X,'WRITE RAW DATA TO A CREATED DISC FILE)'
0052       +/11X,'3    TO SORT AND ASSEMBLE COLLECTED DATA'
0053       +/17X,'(READ RAW DATA FROM ANY DISC LU,'
0054       +/17X,'ASSEMBLE DATA, WRITE TO DISC FILE)'
0055       +/11X,'4    TO COMPUTE TURBULENCE STRESS CORRELATION'
0056       +/17X,'VALUES FROM ASSEMBLED DATA FILES'
0057       +/11X,'5    TO END THIS PROGRAM'//11X,'_')
0058        READ(LU,*) IMODE
```

```
0059         GO TO (100,200,300,400,9999),IMODE
0060   C
0061    100   CONTINUE
0062   C----TEST THE SYSTEM AND WRITE TO ANY NON-DISC LU----------------------C
0063   C
0064   C ASK FOR AMOUNT OF DATA AND OUTPUT LU
0065           ISL=0
0066           IDL=512
0067           ICOUNT=0
0068         WRITE(LU,109)
0069    109   FORMAT(' ENTER # DATA WORDS TO COLLECT(<=512)[I5]: _')
0070         READ(LU,*)IDL
0071         IF(IDL GT.512)IDL=512
0072         WRITE(LU,130)
0073    130   FORMAT(' ENTER OUTPUT LU(I2):  _')
0074         READ(LU,131)IOUT
0075    131   FORMAT(I2)
0076   C
0077   C READ STATIC CONTROL WORDS AND ZERO BUFFER
0078    102   WRITE(LU,103)
0079    103   FORMAT(' ENTER A CONTROL WORD <000000 TO STOP> [O6]: _')
0080         READ(LU,104)IENTER
0081    104   FORMAT(O6)
0082         IF(IENTER.EQ. 0B) GO TO 105
0083         ISL=ISL+1
0084         ISCW(ISL)=IENTER
0085         GO TO 102
0086    105   DO 110 I=1,512
0087    110   IDATA(I)=0
0088         IF(ISL.EQ.0) GO TO 2
0089   C
0090         ICODE=3
0091         CALL DRVR(ICODE,IDATA,ISCW,ISL,ICNT,IFLAG)
0092   C
0093   C WRITE OUT ANY DATA COLLECTED
0094         IF(ICNT.GT.0) WRITE(IOUT,108) (IDATA(I),I=1,ICNT)
0095    108   FORMAT(65(/8(1X,O6)))
0096         WRITE(IOUT,120) ICNT,IFLAG
0097    120   FORMAT(' ICNT = ',I3/' IFLAG = ',I2//)
0098   C
0099   C COLLECTED ENOUGH ?
0100         ICOUNT=ICOUNT+ICNT
0101         IF(ICOUNT.LT.IDL) GO TO 105
0102         GO TO 2
0103   C
0104    200   CONTINUE
0105   C----COLLECT DATA FROM LDV INTERFACE-----------------------------C
0106   C SELECTIONS OF STATIC CONTROL WORDS CAN BE ALTERED/STORED HERE C
0107   C FOR ROUTINE DATA COLLECTIONS. THE DISA MANUALS SHOULD BE      C
0108   C CONSULTED BEFORE MAKING HARDWARE CHANGES  ANY HARDWARE MODI-  C
0109   C FICATION WILL PROBABLY RESULT IN THE NEED TO MODIFY CONTROL   C
0110   C WORDS. THIS IS A GOOD PLACE TO STORE CONTROL WORDS:           C
0111         ISCW(1)=010011B
0112         ISCW(2)=022342B
0113         ISCW(3)=000054B
0114         ISL=3
0115         IDL=512
0116         WAIT=5
0117   C 1. ISCW(1) TURNS ON THE COINCIDENCE FILTER BOARD AND CHANNELS C
0118   C    ONE AND TWO.                                               C
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0119   C 2. ISCW(2) SETS A 125 MICROSEC TIME INTERVAL FOR A 0.1          C
0120   C    MICROSEC TIME BASE FOR THE COINCIDENCE FILTER BOARD.         C
0121   C 3. ISCW(3) SAMPLES BOTH PART CHANNELS OF CHANNELS 1,2 AND 4,    C
0122   C    CORRESPONDING TO P1,P2 AND P4 ON THE INPUT MULTIPLEXER       C
0123   C    BOARD.                                                       C
0124   C 4. THE DRIVER ASSUMES THAT THE ADDRESS TO DROP REQUEST B IS     C
0125   C    SET AS 6B (THE SWITCH ON THE 57GXXX BORD IS ON 6)            C
0126   C TAKE DATA CALLING USER WRITTEN DRIVER AND PASS THE FOLLOWING    C
0127   C VARIABLES:                                                      C
0128   C ICODE         : =1 PERFORM INITIATION SECTION OF DRIVER ONLY     C
0129   C                   (CLEAR BUFFER MEMORY AND SEND CONTROL WORDS)   C
0130   C                   =2 PERFORM CONTINUATION SECTION ONLY           C
0131   C                   (COLLECT ANY DATA IN BUFFER MEMORY)            C
0132   C                   =3 DO BOTH SECTIONS WITHOUT RETURNING TO THIS  C
0133   C                      PROGRAM IN BETWEEN                          C
0134   C IDATA(512)    : INTEGER ARRAY OF DATA TRANSFER WORDS COLLECTED   C
0135   C IDL           : INTEGER NUMBER OF DATA SAMPLES TO COLLECT(=<512) C
0136   C ISCW(10)      : INTEGER BUFFER OF CONTROL WORDS TO SEND TO THE   C
0137   C                   57G20 CONTROL SYSTEM.THE LAST WORD SHOULD BE   C
0138   C                   THE STATIC CONTROL WORD (SCW).                 C
0139   C ISL           : INTEGER NUMBER OF CONTROL WORDS TO BE SENT.      C
0140   C ICNT          : # OF DATA WORDS COLLECTED BY THE DRIVER          C
0141   C                   (INITIATED AT THE BEGINNING OF EVERY CALL)     C
0142   C IFLAG        =1 MEANS THAT THE DRIVER COLLECTED DATA NORMALLY.   C
0143   C              =2 THE DRIVER HAD TO WAIT TOO LONG FOR THE FLAG     C
0144   C                 FLIP-FLOP TO SET WHILE RTE WAS SUSPENDED.       C
0145   C NOTE THAT IDATA BUFFER IS NOT CODED ON DISC IN ASCII CHARCTR     C
0146   C SET. THUS IT IS IMPOSSIBLE TO SEE THIS DATA W/OUT SOFTWARE.      C
0147   C IN ADDITION, THE DATA BUFFER IS NOT ZEROED BETWEEN DRVR CALLS    C
0148   C TO SAVE TIME. THIS PROGRAM KNOWS HOW MANY NEW WORDS HAVE BEEN    C
0149   C COLLECTED BY THE COUNTER ICNT. THUS ONLY THE FIRST ICNT WORDS    C
0150   C IN BUFFER IDATA HAVE BEEN COLLECTED AFTER ANY DRVR CALL!         C
0151   C-------------------------------------------------------------------C
0152         COUNT=0.0
0153         DATA TITLE/40*2H  /
0154   C
0155   C GET INFORMATION FROM USER
0156         WRITE(LU,211)
0157    211  FORMAT(5X,' ENTER CARTRIDGE #, OUTPUT FILE NAME[I2,A6] _')
0158         READ(LU,202) ICR,NAME
0159    202  FORMAT(I2,1X,3A2)
0160         WRITE(LU,204)
0161    204  FORMAT(5X,' ENTER APPROXIMATE TIME IN'
0162        +/6X,' SECONDS TO COLLECT DATA(I10): _')
0163         READ(LU,208) STIME
0164    208  FORMAT(I10)
0165         WRITE(LU,209)
0166    209  FORMAT(5X,' ENTER A TITLE[A36]')
0167         READ(LU,210)(TITLE(I),I=2,20)
0168    210  FORMAT(20A2)
0169   C
0170   C CREATE AND OPEN A TYPE 3 SEQ. ACCESS FILE
0171         ISIZE=-1
0172         IOPTN=0
0173         ITYP=3
0174         ISECU=0
0175         IDCBS=640
0176         CALL CREAT(IDCB,IERR,NAME,ISIZE,ITYP,ISECU,ICR,IDCBS)
0177         IF(IERR.LT.0) CALL ERR(1,IEPR,1)
0178         CALL OPEN(IDCB,IERR,NAME,IOPTN,ISECU,ICR,IDCBS)
```

```
0179          IF(IERR.LT.0) CALL ERR(2,IERR,2)
0180    C
0181    C WRITE OUT A TITLE
0182          NWORDS=20
0183          CALL WRITF(IDCB,IERR,TITLE,NWORDS)
0184          IF(IERR.LT.0) CALL ERR(5,IERR,3)
0185    C
0186    C GET STARTING TIME
0187          CALL EXEC(11,ITIME,IYEAR)
0188          FTI=(ITIME(4)*60+ITIME(3))*60+ITIME(2)
0189    C
0190    C COLLECT AND WRITE OUT A BUFFER OF DATA
0191      203 ICODE=1
0192          CALL DRVR(ICODE,IDATA,IDL,ISCW,ISL,ICNT,IFLAG)
0193               CALL EXEC(11,ITIME,IYEAR)
0194               TTW=(ITIME(4)*60+ITIME(3))*60+ITIME(2)
0195      205           CALL EXEC(11,ITIME,IYEAR)
0196                    NTW=WAIT+(ITIME(4)*60+ITIME(3))+ITIME(2)
0197                    IF(NTW.LT.TTW) GO TO 205
0198          ICODE=2
0199          CALL DRVR(ICODE,IDATA,IDL,ISCW,ISL,ICNT,IFLAG)
0200    C
0201    C  WRITE BUFFER TO TERMINAL, IF DESIRED
0202    D     IF(ICNT.GT.0) WRITE(LU,108)(IDATA(I),I=1,ICNT)
0203    D     WRITE(LU,120) ICNT,IFLAG
0204    C
0205    C  WRITE OUT DATA TO DISC FILE
0206          IF(ICNT.GT.0) CALL WRITF(IDCB,IERR,IDATA,ICNT)
0207          IF(IERR.LT.0) CALL ERR(5,IERR,5)
0208          COUNT=COUNT+ICNT
0209    C
0210    C CHECK TIME
0211          CALL EXEC(11,ITIME,IYEAR)
0212          TTI=(ITIME(4)*60+ITIME(3))*60+ITIME(2)
0213          DT=TTI-FTI
0214          IF(DT.LT.STIME) GO TO 203
0215          RATE=COUNT/DT
0216    C
0217    C WRITE OUT # SAMPLES AND CLOSE THE DISC FILE
0218          WRITE(LU,207) COUNT,RATE,NAME,ICR
0219       207  FORMAT(10X,' SAMPLING TIME OVER!'
0220           +/10X,G15.3,' DATA WORDS COLLECTED'/7X,'AT ',G15.3,
0221           +' WORDS/SEC'/7X,'ON ',3A2,'::',I2//)
0222          CALL LOCF(IDCB,IERR,IREC,IRB,IOFF,JSEC)
0223          IF(IERR.LT.0) CALL ERR(3,IERR,6)
0224          ITRUN=JSEC/2-IRB-1
0225          CALL CLOSE(IDCB,IERR,ITRUN)
0226          IF(IERR.LT.0) CALL ERR(4,IERR,7)
0227    C
0228    C GO BACK TO COMMAND SECTION
0229          GO TO 2
0230    C
0231    C------SORT & REDUCE RAW DATA FILES-------------------------------------
0232       300  CONTINUE
0233    C
0234    C PREPARE INPUT DISC FILE WITH RAW DATA
0235          IOPTN=0
0236          ITYP=3
0237          ISIZE=-1
0238          ISECU=0
```

```
0239          IDCBS=640
0240          IDCBS2=128
0241          WRITE(LU,304)
0242    304   FORMAT(5X,' ENTER CARTRIDGE # ,INPUT FILE NAME [I2,A6] _')
0243          READ(LU,202) ICR,NAME
0244          CALL OPEN(IDCB,IERR,NAME,IOPTN,ISECU,ICR,IDCBS)
0245          IF(IERR.LT.0) CALL ERR(2,IERR,8)
0246    C
0247    C CREATE AND OPEN OUTPUT FILE
0248          WRITE(LU,211)
0249          READ(LU,202)IOUT,NAME2
0250          CALL CREAT(IDCB2,IERR,NAME2,ISIZE,ITYP,ISECU,IOUT,IDCBS2)
0251          IF(IERR.LT.0)CALL ERR(1,IERR,9)
0252          CALL OPEN(IDCB2,IERR,NAME2,IOPTN,ISECU,IOUT,IDCBS2)
0253          IF(IERR.LT.0) CALL ERR(2,IERR,10)
0254    C
0255    C WRITE ASSEMBLED DATA TO A NON-DISC LU, IF DESIRED
0256    D     WRITE(LU,305)
0257    D305  FORMAT(5X,' ENTER A NON-DISC LU TO SEE ASSEMBLED DATA:  _')
0258    D     READ(LU,131) ILU
0259    D     WRITE(LU,306) ILU
0260    D306  FORMAT(5X,' DO YOU NEED TO CONTROL LU ',I2,' ?[Y/N] _')
0261    D     READ(LU,307) IANS
0262    D307  FORMAT(A1)
0263    D     IF(IANS.EQ.1HY) CALL TAPE(ILU)
0264    C
0265    C READ IN TITLE AND WRITE TO OUTPUT FILE
0266          NWORDS=20
0267          CALL READF(IDCB,IERR,IBUFF,NWORDS,ILEN)
0268          IF(IERR.LT.0) CALL ERR(4,IERR,11)
0269          CALL WRITF(IDCB2,IERR,IBUFF,NWORDS)
0270          IF(IERR.LT.0) CALL ERR(5,IERR,12)
0271          NCHRS=40
0272          CALL CODE(NCHRS)
0273          READ(IBUFF,210)(TITLE(I),I=1,20)
0274    C
0275    C INITIATE STATISTICAL QUANTITIES, IPASS=1
0276          IPASS=1
0277          CALL STAT(IPASS,ICNTR,RDATA,ITYPE)
0278    C
0279    C CALL FIRST PRINTING ROUTINE, IF DESIRED
0280    D     CALL PRINI(TITLE,ILU)
0281    C
0282    C READ IN A RECORD OF DATA OF UP TO 512 WORDS
0283          NCHRS=22
0284          NWRDS=11
0285          NWORDS=512
0286          IPASS=2
0287      309 CONTINUE
0288          DO 308 I=1,512
0289      308 IDATA(I)=0
0290          CALL READF(IDCB,IERR,IDATA,NWORDS,ILEN)
0291          IF(IERR.LT.0) CALL ERR(6,IERR,14)
0292          IF(ILEN.LT.0) GO TO 311
0293    C
0294    C PROCESS THE DATA ON A RECORD
0295          ISKIP=0
0296          DO 310 I=1,ILEN
0297    C
0298    C          ASSEMBLE THE DTW INFORMATION
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```
0299          CALL ASMBL(IDATA(I),PARTCH,PLOC,FORM1,FORM2,IBO,ITO)
0300  C
0301  C         SORT THE INFORMATION IN THE DTW
0302          CALL SORT(IDATA(I),PARTCH,PLOC,ITYPE,ICNTR,FORM1,FORM2,RDATA)
0303          IF(ITYPE.EQ 6) GO TO 310
0304  C
0305  C         PRINT/WRITE THE DATA, IF DESIRED
0306  D       CALL PRIN2(ICNTR,ITYPE,RDATA,IBO,ITO,ILU)
0307  C
0308  C         DO STATISTICAL SUMMATIONS, IPASS=2
0309          CALL STAT(IPASS,ICNTR,RDATA,ITYPE)
0310  C
0311  C         GROUP VELOCITY & INTRVL DATA (PER BURST)& WRITE TO OUTPUT FILE
0312          CALL GATHR(ISKIP,ICNTR,ITYPE,RDATA,IDCB2)
0313   310  CONTINUE
0314  C
0315  C READ THE NEXT RECORD IN THE FILE
0316        GO TO 309
0317  C
0318  C DO FINAL STATISTICAL COMPUTATIONS ON A BUFFER OF DATA, IPASS=3
0319   311  IPASS=3
0320        CALL STAT(IPASS,ICNTR,RDATA,ITYPE)
0321  C
0322  C CLOSE THE OUTPUT FILE
0323        CALL LOCF(IDCB2,IERR,IREC,IRB,IOFF,JSEC)
0324        IF(IERR.LT.0) CALL ERR(3,IERR,16)
0325        ITRUN=JSEC/2-IRB-1
0326        CALL CLOSE(IDCB2,IERR,ITRUN)
0327        IF(IERR.LT.0) CALL ERR(4,IERR,17)
0328  C
0329  C PLACE EOF ON ILU IF IT IS A TAPE
0330        ICNWD=ILU+100B
0331        CALL EXEC(3,ICNWD,0)
0332  C
0333  C RETURN TO COMMAND SECTION
0334        GO TO 2
0335  C-----------------------------------------------------------------C
0336   400  CONTINUE
0337  C----COMPUTE REYNOLDS STRESSES-----------------------------------C
0338   9999 WRITE(LU,9998)
0339   9998 FORMAT(10X,'**END OF LDV**')
0340        END
0341  C*****************************************************************C
0342        SUBROUTINE SORT(IDATA,PARTCH,PLOC,ITYPE,ICNTR,FORM1,
0343       +FORM2,RDATA),  TO DECIPHER DTW'S
0344        COMMON LU(5)
0345        INTEGER P1234(4),DIGIO(4),MODE(4),PARTCH,PLOC
0346        REAL FSHIFT(4),LAMBDA(4),THETA(4),FORM1,FORM2,TBASE,RDATA
0347  C-----------------------------------------------------------------C
0348  C***** NOTICE TO USER MAKING MODIFICATIONS *****                  C
0349  C INDICATE DEVICES CONNECTED TO THE 57G120 INPUT MULTIPLEXER :    C
0350  C  THE USER TELLS THIS PROGRAM HOW THE 57G20 CABLES ARE CON-     C
0351  C    NECTED BY SETTING THE MEMBERS OF THE FOLLOWING ARRAYS:      C
0352  C    P1234(X)=Y WHERE     X=1,2,3, OR 4 CORRESPONDING TO PINS    C
0353  C                           P1,P2,P3,P4 RESPECTIVELY.            C
0354  C                         Y=1,2 FOR COUNTER WHICH WILL BE REF-   C
0355  C                               ERENCED AS 1,2                   C
0356  C                         Y=9 FOR THE COINCIDENCE FILTER BOARD   C
0357  C                         Y=0 IF NOTHING IS CONNECTED AT ALL     C
0358  C                           OR FOR THE COINCIDENCE FILTER BOARD  C
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0359  C     DIGIO(X)=A WHERE     X IS THE SAME AS ABOVE                    C
0360  C                          A=1 IF THE DIGITAL I/O SLOT #1 CORRES     C
0361  C                            TO PIN X OR A=2 IF DIGITAL I/O SLOT     C
0362  C                            #2 APPLIES.                             C
0363  C                          A=0 IF A COUNTER IS NOT CONNECTED         C
0364  C     FSHIFT(X)=B  WHERE   X IS THE SAME AS ABOVE                    C
0365  C                          B IS THE FREQUENCY SHIFT AS SHOWN ON      C
0366  C                            THE 55N14 FREQ GENERATOR, I E  B IS     C
0367  C                            POSITIVE IF THE >40MHZ SIDE IS USED     C
0368  C                            AND NEGATIVE IF <40MHZ  B IS ONLY THEC
0369  C                            VALUE SET ON THE 55N14 PANEL            C
0370  C     MODE(X)=C    WHERE   X IS THE SAME AS ABOVE                    C
0371  C                          C=1 IF DATA IS COLLECTED IN THE FIXED     C
0372  C                            MODE ON THE COUNTER PROCESSOR,          C
0373  C                          C=2 IF THE COMBINED MODE IS USED.         C
0374  C                          C=3 IF THE VARIABLE FRINGE MODE, AND      C
0375  C                          C=4 IF THE TRANSIT MODE IS USED.          C
0376  C                          C=9 IF NO COUNTER IS ON X.                C
0377  C      TBASE              IS THE FLOATING POINT CLOCK TIME BASE     C
0378  C                         ON JUMPER S2 OF THE CFB. IT  MAY BE 0.1 C
0379  C                         1, OR 10 USEC.                            C
0380  C      LAMDA(X)=D    WHERE X IS THE SAME AS ABOVE                    C
0381  C                          D IS THE WAVELENGTH OF LASER EMR USED     C
0382  C                          ON CHANNEL X.                             C
0383  C      THETA(X)=E   WHERE   X IS THE SAME AS ABOVE.                   C
0384  C                          E IS THE ANGLE BETW/ THE CORRES. BEAMS C
0385  C                            ASSOC W/ THIS COUNTER (FOR COAXIAL      C
0386  C                            BEAMS THIS IS ALWAYS CONSTANT)          C
0387  C
0388        DATA P1234/2,1,0,9/
0389        DATA DIGIO/2,2,0,0/
0390        DATA FSHIFT/-10.0E+03,-10.0E+03,0.0,0.0/
0391        DATA MODE/1,1,9,9/
0392        DATA TBASE/0.1E-06/
0393        DATA LAMBDA/ 488.0E-09,514.5E-09,0.0,0.0/
0394        DATA THETA/0.019330253,0.019701965,0.0,0.0/
0395  C
0396  C-------------------------------------------------------------C
0397  C ITYPE IDENTIFIES THE TYPE OF INFORMATION THAT A DATUM GIVES: C
0398  C ITYPE= 1 FOR DOPPLER FREQUENCY DATA                          C
0399  C        2 FOR SAMPLE INTERVAL DATA,                           C
0400  C        3 FOR NUMBER OF FRINGES,                              C
0401  C        4 FOR BURST TIME DATA,                                C
0402  C        5 FOR VELOCITY DATA, AND                              C
0403  C        6 IDATA=0                                             C
0404  C-------------------------------------------------------------C
0405  C
0406  C IDENTIFY THE TYPE OF DATA
0407        ITYPE=DIGIO(PLOC)*PARTCH
0408        IF(ITYPE.EQ.2 AND.PARTCH.EQ.1B) ITYPE=3
0409  C SAMPLE INTERVAL HAS ONLY ONE PART CHANNEL OF INFO:
0410        IF(P1234(PLOC) EQ 9 AND.PARTCH.EQ 1B) ITYPE=2
0411        IF(P1234(PLOC) EQ 9 AND PARTCH EQ 2B) ITYPE=6
0412        IF(IDATA.EQ.0) ITYPE=6
0413  C
0414  C CONVERT DIGITAL OUTPUT TO DOPPLER FREQ, BURST/TRANSIT TIME,
0415  C NUMBER OF FRINGES, OR SAMPLE INTERVAL TIME  THIS IS DONE AS
0416  C PRESCRIBED ON P27 OF DISA COUNTER INSTRUCTION MANUAL. ALSO
0417  C SUBTRACT FREQUENCY SHIFTING AND CONVERT TO FREQUENCY TO VELOCITY.
0418        IF(MODE(PLOC).GT.2) GO TO 353
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0419            IF(ITYPE.EQ.1) RDATA=FORM1*14.96+FSHIFT(PLOC)
0420            IF(ITYPE.EQ.4) RDATA=16.E+09/FORM1+FSHIFT(PLOC)
0421            IF(ITYPE.EQ.4) ITYPE=1
0422     357    IF(MODE(PLOC).LE.2) GO TO 354
0423            IF(ITYPE.EQ.1) RDATA=0.5348/FORM1+FSHIFT(PLOC)
0424            IF(ITYPE.EQ.4) RDATA=0.5E-09*FORM1+FSHIFT(PLOC)
0425            IF(ITYPE.EQ.4) ITYPE=1
0426    C CONVERT DOPPLER FREQUENCY TO VELOCITY
0427     354    IF(ITYPE.NE.1) GO TO 355
0428    C.D)    IF(1.EQ.1) GO TO 355
0429            FACTOR=LAMBDA(PLOC)/(2.*SIN(THETA(PLOC)/2.))
0430            RDATA=.RDATA*FACTOR
0431            ITYPE=5
0432     355    IF(ITYPE.EQ.2) RDATA=.FORM1*TBASE
0433            IF(ITYPE.EQ.3) RDATA=.FORM2
0434    C
0435    C IDENTIFY WHICH COUNTER
0436            ICNTR=P1234(PLOC)
0437    C
0438    C LEAVE
0439            RETURN
0440            END
0441    C*****************************************************************
0442            SUBROUTINE GATHR(ISKIP,ICNTR,ITYPE,RDATA,IDCB2),  TO GROUP DATA BY
0443           + BURSTS
0444            COMMON LU(5)
0445            DIMENSION IBUFF(33),ITYP(10),ICNT(10),RDAT(10)
0446            IADDRS=ICNTR*ITYPE
0447    C
0448    C  IF THIS IS THE FIRST CALL, SAVE THE FIRST ADDRESS
0449            IF(ISKIP.EQ.0)GO TO 506
0450    C
0451    C  IF IT IS NOT THE FIRST CALL, CHECK TO SEE IF ADDRESS EQUALS
0452    C  FIRST ADDRESS
0453            IF(IADDRS.NE.IAD)GO TO 522
0454    C
0455    C  IF ADDRESS EQUALS FIRST ADDRESS,ZERO THE ARRAY, AND RESET IPTR
0456      521   IPTR=0
0457            DO 508 I=1,3
0458            ITYP(I)=0
0459            ICNT(I)=0
0460            RDAT(I)=0.0
0461      508   CONTINUE
0462    C
0463    C   IF DATA IS VELOCITY OR SAMPLE INTERVAL DATA WRITE IN ARRAY
0464      522   IF(ITYPE.NE.2 AND.ITYPE.NE.5) RETURN
0465            IPTR=IPTR+1
0466            ISKIP=1
0467            IDUM=ICNTR
0468            IF(ITYPE.EQ.2)IDUM=3
0469            ITYP(IDUM)=ITYPE
0470            ICNT(IDUM)=ICNTR
0471            RDAT(IDUM)=RDATA
0472    C
0473    C  IF ARRAY IS FULL, WRITE ARRAY TO BUFFER
0474            IF(IPTR.NE.3) RETURN
0475            CALL CODE(NCHRS)
0476            WRITE(IBUFF,501)(ICNT(IPTR),ITYP(IPTR),RDAT(IPTR),IPTR=1,3)
0477      501   FORMAT(3(1X,I2,1X,I2,1X,G15.8))
0478    C
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0479  C    WRITE DATA IN BUFFER TO OUTPUT FILE & RETURN
0480         CALL WRITF(IDCB2,IERR,IBUFF,NWRDS)
0481         IF(IERR.LT.0)CALL ERR(5,IERR,15)
0482         RETURN
0483  C
0484  C  IF FIRST CALL, SAVE FIRST ADDRESS IN VARIABLE IAD, AND
0485  C  THEN ZERO THE BUFFER
0486    506 IAD=IADRS
0487         NCHRS=66
0488         NWRDS=33
0489         GO TO 521
0490         END
0491  C*************************************************************C
0492         SUBROUTINE STAT(IPASS,ICNTR,DATA,ITYPE),  TO DO STATISTICS
0493         COMMON LU(5)
0494         REAL MAG,ANGL,SUM1,SUM2,AVG1,AVG2
0495         INTEGER N1,N2
0496         GO TO (100,200,300),IPASS
0497  C
0498  C INITIATE QUANTITIES
0499   100   CONTINUE
0500         N1=0
0501         N2=0
0502         SUM1=0
0503         SUM2=0
0504         RETURN
0505  C
0506  C DO SUMMATIONS, ETC
0507   200   CONTINUE
0508         IF(ITYPE.NE.5) RETURN
0509         IF(ICNTR.NE.1) GO TO 201
0510         N1=N1+1
0511         SUM1=SUM1+DATA
0512         RETURN
0513   201   N2=N2+1
0514         SUM2=SUM2+DATA
0515         RETURN
0516  C
0517  C FINISH CALCULATIONS
0518   300   CONTINUE
0519         AVG1=SUM1/N1
0520         AVG2=SUM2/N2
0521         MAG=SQRT(AVG1*AVG1+AVG2*AVG2)
0522         ANGL=ATAN(AVG2/AVG1)
0523         ANGL=ANGL*180/3.141592654
0524         WRITE(6,301) AVG1,AVG2,MAG,ANGL
0525         WRITE(LU,301) AVG1,AVG2,MAG,ANGL
0526   301   FORMAT(///'  UNWEIGHTED MEAN VELOCITIES:'
0527        +/' (CNTR 1) ',G15.8/' (CNTR 2) ',G15.8
0528        +///'  RESULTANT VECTOR: '/' MAGNITUDE = ',G15.8
0529        +/' INCLUDED ANGLE = ',G15.8//)
0530         RETURN
0531         END
0532  C*************************************************************C
0533         SUBROUTINE ASMBL(DTW,PARTCH,PLOC,FORM1,FORM2,IBO,ITO),  ASSEMBLE
0534        + DATA FROM  DTW'S
0535  C THE FORMAT OF P,D, & T TYPE DATA:
0536  C  ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
0537  C  + DTC + B0 CC1 CC2 + M7 E3 E2 + E1 E0 M6 + M5 M4 M3 + M2 M1 M0 +
0538  C  ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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0539   C THE FORMAT OF FRINGE DATA:
0540   C  ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
0541   C  + DTC + 80 CC1 CC2 +    F7 F6 + F5 F4 F3 + F2 F1 F0 +          +
0542   C  ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
0543         COMMON LU(5)
0544         INTEGER DTW,PARTCH,PLOC,IBO,ITO,IMAN,IEXP
0545         REAL FORM1,FORM2
0546         PARTCH=IAND(DTW,100000B)/100000B+1B
0547         PLOC=IAND(DTW,030000B)/10000B+1B
0548         IBO=IAND(DTW,40000B)/40000B
0549         ITO=IAND(DTW,4000B)/4000B
0550         IMAN=IAND(DTW,177B)+ITO*200B
0551         IEXP=IAND(DTW,3600B)/200B
0552         FORM1=IMAN*(2.**IEXP)
0553         FORM2=IAND(DTW,37700B)/10B
0554         RETURN
0555         END
0556   C*****************************************************************C
0557         SUBROUTINE PRIN1(TITLE,ILU),  FIRST PRINTING ROUTINE
0558         COMMON LU(5)
0559         INTEGER ISCW(10),TITLE(20),STARS(40)
0560         DATA STARS/2H  ,39*2H**/
0561    10   WRITE(ILU,11) (TITLE(I),I=1,20),(STARS(I),I=1,40)
0562    11   FORMAT(1H1,20A2/1X,'COUNTER #',
0563        +6X,'PART CHANNEL',15X,'DATA SENT',5X,'OVFLOW BIT',3X,'TIME OUT'
0564        +/40A2)
0565         RETURN
0566         END
0567   C*****************************************************************C
0568         SUBROUTINE PRIN2(CNTR,ITYPE,RDATA,IBO,ITO,ILU),  SECOND PRINT ROUT
0569        +INE
0570         COMMON LU(5)
0571         INTEGER CNTR,PARTCH,IBO,ITO,ALPHA(15,5)
0572         REAL RDATA
0573         DATA ALPHA/2HDO,2HPP,2HLE,2HR ,2HFR,2HEQ,2HUE,2HNC,2HY ,6*2H  ,
0574        +2HSA,2HMP,2HLE,2H I,2HNT,2HER,2HVA,2HL ,7*2H  ,
0575        +2H# ,2HOF,2H F,2HRI,2HNG,2HES,9*2H  ,
0576        +2HBU,2HRS,2HT ,2HTI,2HME,10*2H  ,
0577        +2HVE,2HLO,2HCI,2HTY,11*2H  /
0578   C DO NOT PRINT THE SAME DATUM OVER & OVER
0579   C      IF(RDATA.EQ.PDATA) RETURN
0580   C      PDATA=RDATA
0581         WRITE(ILU,10) CNTR,(ALPHA(I,ITYPE),I=1,15),RDATA,IBO,ITO
0582    10   FORMAT(5X,I1,8X,15A2,G15.4,9X,I1,8X,I1)
0583         RETURN
0584         END
0585   C*****************************************************************C
0586         SUBROUTINE ERR(IPASS,IERR,ILOC),  TO FIND DISC & SOFTWARE ERRORS
0587   C
0588         COMMON LU(5)
0589   C
0590         IF(IPASS.EQ.1) WRITE(LU,1)IERR,ILOC
0591         IF(IPASS.EQ.2) WRITE(LU,2)IERR,ILOC
0592         IF(IPASS.EQ.3) WRITE(LU,3)IERR,ILOC
0593         IF(IPASS.EQ.4) WRITE(LU,4)IERR,ILOC
0594         IF(IPASS.EQ.5) WRITE(LU,5)IERR,ILOC
0595         IF(IPASS.EQ.6) WRITE(LU,6)IERR,ILOC
0596         IF(IERR GE.0) RETURN
0597         STOP
0598   C
```

```
0599      1  FORMAT('<<CREAT MESSAGE>>IERR= ',I4,' AT ',I2)
0600      2  FORMAT('<<OPEN  MESSAGE>>IERR= ',I4,' AT ',I2)
0601      3  FORMAT('<<LOCF  MESSAGE>>IERR= ',I4,' AT ',I2)
0602      4  FORMAT('<<CLOSE MESSAGE>>IERR= ',I4,' AT ',I2)
0603      5  FORMAT('<<WRITF MESSAGE>>IERR= ',I4,' AT ',I2)
0604      6  FORMAT('<<READF MESSAGE>>IERR= ',I4,' AT ',I2)
0605     10  FORMAT('*****TIME OUT ERROR*****'
0606        +/'*****BUFFER OVERFLOW*****',I6)
0607         END
0608  C*************************************************************C
0609         SUBROUTINE TAPE(TAPELU),  TO CONTROL A TAPE LU BY PROGRAN
0610  C I AM A GEN PURPOSE ROUTINE TO DO NEAT THINGS TO ANY MAG-   C
0611  C NETIC TAPE DRIVE.                                          C
0612  C-------------------------------------------------------------C
0613         COMMON LU(5)
0614         INTEGER TAPELU,IBUF(32)
0615   50    WRITE(LU,100) TAPELU
0616  100    FORMAT('-----','ENTER AN OCTAL FUNCTION FOR LU ',I2,' [04]'
0617        +/' 0000 = CLEAR THE DEVICE'
0618        +/' 0100 = WRITE AN EOF'
0619        +/' 0200 = BACKSPACE 1 RECORD'
0620        +/' 0300 = FORWARD SPACE 1 RECORD'
0621        +/' 0400 = REWIND'
0622        +/' 0500 = WRITE AN INTER-RECORD GAP'
0623        +/' 1300 = FORWARD 1 FILE'
0624        +/' 1400 = BACK 1 FILE'
0625        +/' 2700 = LOCATE FILE(CTU ONLY)'
0626        +/' 7777 = READ & LIST A RECORD OF UP TO 32 WORDS'
0627        +/' 1111 = TO GET OUT OF THIS ROUTINE'/'-----_')
0628         READ(LU,101) IFC
0629   101   FORMAT(O4)
0630         IF(IFC.NE.11118) GO TO 112
0631               WRITE(LU,113)
0632   113         FORMAT(' RETURNING TO MAIN PROGRAN')
0633               RETURN
0634   112   IF(IFC.EQ.2700B) GO TO 105
0635         IF(IFC.EQ.7777B) GO TO 110
0636         ICODE=3
0637         IOP1=0
0638   103   CALL EXEC(ICODE,TAPELU+IFC,IOP1)
0639         GO TO 50
0640   105   WRITE(LU,106)
0641   106   FORMAT(10X,'ENTER FILE # TO LOCATE [I2]')
0642         READ(LU,*)IOP1
0643         GO TO 103
0644   110   CALL EXEC(1,TAPELU,IBUF,32)
0645         WRITE(LU,111)(IBUF(I),I=1,32)
0646   111   FORMAT(32A2)
0647         GO TO 50
0648         END
```

APPENDIX C - EXAMPLE: SIX cm METHANOL PAN FIRE

```
RESTI  T=00003 IS ON CR00041 USING 00056 BLKS R=0000

0001     6 CM PAN FIRST DATA POINT
0002              VERTICAL (M)              HORIZONTAL (M)     SAMPLE INT. TIME (SEC)
0003              .14526880              -.21625594E-02          .81100792E-01
0004              .31290054E-02           .43555414E-02          .46202880
0005              .73017776E-02           .57001272E-02          .38174719
0006             -.22369782E-02           .40457380E-03          .23592958
0007             -.22369782E-02          - .71435757E-02         .31948799
0009              .45054266E-02          -.21625594E-02          .69795835
0009             - .91599929E-03           .40457380E-03          .42270720
0010              .63727051E-01           .30249106E-02          .41615355
0011              .16927639               .40457380E-03          .82329601E-01
0012              .16567457               .17079869E-02          .10239999
0013              .17667629E-02           .40457380E-03          .32767999
0014              .31290054E-02           .43555414E-02          .46202880
0015              .31290054E-02           .40457380E-03          .78233600E-01
0016              .45054266E-02          -.21625594E-02          .71434236
0017              .41849620E-03           .40457380E-03          .57671678
0018              .31290054E-02           .17079869E-02          .14581758
0019              .31290054E-02           .17079869E-02          .11796479
0020              .31290054E-02           .17079869E-02          .60293114
0021              .31290054E-02           .40457380E-03          .31293440
0022              .26740372               .40457380E-03          .38830078
0023              .41849620E-03          -.21625594E-02          .64225280
0024              .13424206              -.21625594E-02          .24739838
0025              .57635680E-01          -.88552607E-03          .31743996E-01
0026              .43755323               .30249106E-02          .44236797
0027              .58962824E-02           .43555414E-02          .49479675
0028              .73017776E-02           .30249106E-02          .53084159
0029             -.22369782E-02           .40457380E-03          .17121279
0030              .44725734               .30249106E-02          .50135040
0031              .87221134E-02           .57001272E-02          .41123837
0032             10.004017                .17079869E-02          .63487992E-01
0033              9.1733093               .30249106E-02          .10158080
0034              4.6847963               .40457380E-03          .18022400
0035             14.246948                .40457380E-03          .86425588E-01
0036             13.454493               -.88552607E-03          .10813439
0037              .31290054E-02           .43555414E-02          .62586880
0038              6.5395241              -.88552607E-03          .43212794E-01
0039              4.7763882               .43555414E-02          .32767999
0040              6.6842194               .17079869E-02          .32767999
0041              7.6619654                17079869E-02          .54886393E-01
0042             10.337299                .30249106E-02          .66764802E-01
0043              .15864873              -.88552607E-03          .49807358
0044              .41849620E-03           .30249106E-02          .19496959
0045               31290054E-02           .40457380E-03          .83558393
0046              .15522179               .17079869E-02          .50135040
0047              .55655666E-01          -.59169848E-02          .28671998
0048              .73017776E-02           .30249106E-02          .50135040
0049              .59640586E-01           .30249106E-02          .70451200
0050              .41849620E-03          -.21625594E-02          .42270720
0051               61670892E-01           .17079869E-02          .49807358
0052              .41849620E-03           .30249106E-02          .69468153
0053             -.91599929E-03          -.88552607E-03          .65945596E-01
0054              .58962824E-02           .30249106E-02          .13926399
0055              .99823773               .40457380E-03          .31293440
0056              .15692824              -.88552607E-03          .55705595
0057              .41849620E-03           .40457380E-03          .66846716
0058              .45221126               .40457380E-03          .80936956
```

0059	.59608161	-.88552607E-03	.12779519
0060	.17667629E-02	.43555414E-02	.54722559
0061	.12525600	.40457380E-03	.33587199
0062	.31290054E-02	.30249106E-02	.40468478
0063	.31290054E-02	.57001272E-02	.38830078
0064	-.22369782E-02	.30249106E-02	.27033597E-01
0065	.31290054E-02	.40457380E-03	.27361280
0066	-.73894039E-02	.17079869E-02	.11960319
0067	-.91599929E-03	.17079869E-02	.74055672
0068	.44725734	.17079869E-02	.71434236
0069	.41849620E-03	.30249106E-02	.33095676
0070	.58962824E-02	.43555414E-02	.24412158
0071	.17667629E-02	.57001272E-02	.61276162
0072	.17667629E-02	.17079869E-02	.54722559
0073	.37129261E-01	.17079869E-02	.11468799
0074	.45054266E-02	.57001272E-02	.64552951
0075	.17667629E-02	.17079869E-02	.29982716
0076	-.91599929E-03	.40457380E-03	.63242233
0077	.45054266E-02	.30249106E-02	.56688643
0078	.63727051E-01	.43555414E-02	.17940480
0079	.41849620E-03	.17079869E-02	.72089601
0080	.31290054E-02	.57001272E-02	.32604158
0081	17.288971	-.88552607E-03	.14335999
0082	5.4457102	.30249106E-02	.14663678
0083	1.5851901	.30249106E-02	.78643203E-01
0084	.45054266E-02	-.88552607E-03	.57343996
0085	.72924316	.40457380E-03	.50790393
0086	-.91599929E-03	-.21625594E-02	.31293440
0087	.16746795	.43555414E-02	.36864001
0088	.61670892E-01	.30249106E-02	.81592309
0089	.45054266E-02	.17079869E-02	.57343996
0090	-.22369782E-02	.30249106E-02	.72089601
0091	.41849620E-03	.40457380E-03	.86835191E-01
0092	.17667629E-02	.17079869E-02	.11468799
0093	.17667629E-02	.40457380E-03	.21135360
0094	.58962824E-02	.57001272E-02	.71106553
0095	.16927639	.70588645E-02	.37847036
0096	.19425631	.17079869E-02	.82903039
0097	.41849620E-03	.30249106E-02	.32358401E-01
0098	.17667629E-02	.30249106E-02	.31129599
0099	-.91599929E-03	-.88552607E-03	.39157760
0100	.12235069	.40457380E-03	.66191351
0101	.16567457	.17079869E-02	.52428794
0102	.31290054E-02	.30249106E-02	.66355199E-01
0103	.31290054E-02	.17079869E-02	.73072636
0104	.17667629E-02	.17079869E-02	.28999680
0105	.41849620E-03	.17079869E-02	.41779196
0106	.41849620E-03	.40457380E-03	.23756799
0107	.45054266E-02	.17079869E-02	.38993919
0108	.41849620E-03	.30249106E-02	.41287678
0109	.17667629E-02	.17079869E-02	.83558393
0110	.37641710	-.88552607E-03	.42926079
0111	.17110023	-.88552607E-03	.68812799
0112	-.22369782E-02	.17079869E-02	.35717118
0113	.63727051E-01	.30249106E-02	.72089598E-01
0114	.35709697	.40457380E-03	.12533760
0115	.13120064	.40457380E-03	.22282240
0116	-.22369782E-02	.40457380E-03	.24248320
0117	.16567457	.17079869E-02	.16629758
0118	.41849620E-03	.17079869E-02	.69468153

0119	.36468273	.30249106E-02	.50462723
0120	.82406759	-.88552607E-03	.12779519
0121	.31290054E-02	.17079869E-02	.15892479
0122	.16213247	-.21625594E-02	.22609919
0123	-.22369782E-02	.40457380E-03	.43008000E-01
0124	.59640586E-01	17079869E-02	.82247674
0125	17479461	.43555414E-02	.13107198
0126	19629845	.57001272E-02	.70778871
0127	.31290054E-02	17079869E-02	.40468478
0128	.64159811	43555414E-02	.25559038
0129	.31290054E-02	.70588645E-02	.73400319
0130	58962824E-02	.70588645E-02	.20479998
0131	40125716	.40457380E-03	.56360960
0132	17667629E-02	.30249106E-02	.98303989E-01
0133	.58962824E-02	-.88552607E-03	.19824639
0134	.45054266E-02	.70588645E-02	.46202880
0135	31290054E-02	.40457380E-03	.44564480
0136	59640586E-01	17079869E-02	.27361280
0137	-.13548516E-01	-.10751111E-01	.73728001
0138	41849620E-03	.30249106E-02	.73728001
0139	.31290054E-02	.57001272E-02	.17694718
0140	59640586E-01	17079869E-02	.64225280
0141	-.22369782E-02	.30249106E-02	.83558393
0142	62205803	.30249106E-02	.15400958
0143	.40558666	-.88552607E-03	.78643191
0144	.31290054E-02	.30249106E-02	.44564480
0145	45054266E-02	17079869E-02	.70451200
0146	.41849620E-03	.70588645E-02	.43581438
0147	41849620E-03	.43555414E-02	.80936956
0148	.41849620E-03	.40457380E-03	.47513598
0149	.31290054E-02	.30249106E-02	.93388796E-01
0150	.87221134E-02	-.88552607E-03	.59310079
0151	31290054E-02	.43555414E-02	.80936956
0152	.58962824E-02	.30249106E-02	.60293114
0153	-.91599929E-03	.40457380E-03	.36208636
0154	17667629E-02	.40457380E-03	.15646720
0155	.31290054E-02	.17079869E-02	.11304960
0156	.41849620E-03	-.88552607E-03	.39976960
0157	17667629E-02	.57001272E-02	.36864001
0158	.44725734	.57001272E-02	.54067194
0159	.73017776E-02	.57001272E-02	.71434236
0160	.31290054E-02	.43555414E-02	.27033597E-01
0161	.12235069	.17079869E-02	.13352960
0162	.31290054E-02	.30249106E-02	.77004790E-01
0163	65809533E-01	.30249106E-02	.50135040
0164	.15522179	.17079869E-02	.52101111
0165	-.91599929E-03	-.88552607E-03	.78315520
0166	.41849620E-03	-.88552607E-03	.28508157
0167	.73017776E-02	.43555414E-02	.73400319
0168	45054266E-02	.40457380E-03	.77332473
0169	-.91599929E-03	-.88552607E-03	.10158080
0170	-.91599929E-03	.40457380E-03	.82903039
0171	.84765923	.40457380E-03	.72499201E-01
0172	.38448751	.70588645E-02	.47513598
0173	.41849620E-03	.40457380E-03	.95027193E-01
0174	.59640586E-01	.40457380E-03	.45547515
0175	.73017776E-02	.43555414E-02	.49151999
0176	.61670892E-01	.17079869E-02	.33382401E-01
0177	41849620E-03	.40457380E-03	.26869756
0178	.66202211	30249106E-02	.56360960

```
0179          .41849620E-03        - .88552607E-03        .31293440
0180          .61670892E-01          .40457380E-03        .45875198
0181          .91138351              .40457380E-03        .47513598
0182          .31290054E-02          .40457380E-03        .33259517
0183          .17110023              .43555414E-02        .24412158
0184          .41849620E-03          .43555414E-02        .21954557
0185          .45054266E-02          .57001272E-02        .66191351
0186          .17667629E-02          .40457380E-03        .16957438
0187        - .91599929E-03          .40457380E-03        .53247996E-01
0188          .41849620E-03          .17079869E-02        .21299198E-01
0189          .17667629E-02        - .88552607E-03        .67502081
0190          .45054266E-02          .40457380E-03        .80936956
0191          .41849620E-03          .43555414E-02        .22609919
0192        - .61206026E-02          .57001272E-02        .34078717
0193        - .22369782E-02          .30249106E-02        .14499840
0194        - .13548516E-01          .30249106E-02        .69468153
0195        - .91599929E-03          .40457380E-03        .39321595
0196          .28436261              .30249106E-02        .64307198E-01
0197          .45054266E-02          .43555414E-02        .33751041
0198        - .91599929E-03          .40457380E-03        .11960319
0199          .17667629E-02          .17079869E-02        .23592958
0200          .59640586E-01          .17079869E-02        .69140470
0201          .41849620E-03          .40457380E-03        .90112001E-01
0202          .27015656              .30249106E-02        .78315520
0203          .17667629E-02        - .88552607E-03        .12779519
0204          .98044619E-01        - .21625594E-02        .79953921
0205          .59640586E-01          .17079869E-02        .79953921
0206          .31290054E-02          .30249106E-02        .72908789E-01
0207
0208
0209
0210          UNWEIGHTED MEAN VELOCITIES:
0211        <CNTR 1>     .53307307  M/S
0212        <CNTR 2>     .17951876E-02  M/S
0213
0214          RESULTANT VECTOR:
0215          MAGNITUDE = 0.53307605
0216          INCLUDED ANGLE = 0.19294965 FROM VERTICAL
0217
```


END
FILMED
9-84
DTIC